REGENERATION HISTORY OF THREE TABLE MOUNTAIN PINE / PITCH PINE STANDS IN NORTHERN GEORGIA

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Abstract—A dendrochronology study was conducted on three ridgetop pine communities in northern Georgia to document the current composition and structure, ascertain when the different species became established, and compare their establishment dates with the occurrence of disturbance or drought. Most oaks and pines in these stands date to the early 1900's and became established after major disturbances by disease, logging, and wildfire. The mountain laurel and mixed mesophytic hardwoods became established after the chestnut blight and institution of wildfire control policies. Drought and precipitation appear to have played little role in the establishment of either pine species. Given the ubiquitous presence of hardwoods and the dominance of mountain laurel in the understory, a regime of no disturbance or a single stand-replacing disturbance may not successfully regenerate either pine species in these stands. Numerous low- to moderate-intensity disturbances may be necessary to reduce the hardwood and laurel components and prepare seedbeds for pitch and Table Mountain pine.

INTRODUCTION

The Southern Appalachian Mountains are renown for their diversity of forest types, one of which is the Table Mountain pine (*Pinus pungens*) / pitch pine (*P. rigida*) community. This rare forest type is found throughout the region on xeric mid-elevational south- and west-facing ridges (Zobell 1969). These species are thought to be fire dependant because of cone serotiny in Table Mountain pine, extreme shade intolerance and exposed seedbed requirements by both species, and a successional shift to hardwoods in the absence of fire (Williams and Johnson 1992). The fire regime for successful regeneration of pitch and Table Mountain pine is thought to be infrequent high-intensity fire, the type of fire that now rarely occurs due to the successful fire control policies of the past 70-80 years (Welch and others 2000).

Recent research has not conclusively shown that high-intensity prescribed fires are absolutely necessary, or even beneficial, in perpetuating Table Mountain pine / pitch pine communities. Waldrop and Brose (1999) analyzed the effects of varying fire intensity levels on successful establishment of Table Mountain pine regeneration. They found the fewest new stems and lowest stocking on sites that had experienced a high-intensity crown fire while the most new stems and highest stocking occurred on sites treated with a moderate-intensity surface fire. However, other low- and moderate-intensity prescribed fires have not resulted in successful establishment of new pine regeneration (Elliot and others 1999, Welch and others 2000).
If fire was an integral part of the perpetuation of Table Mountain pine / pitch pine stands but high-intensity, stand-replacing prescribed fires are not adequately regenerating them, then what was the disturbance regime under which these stands originated and developed? Dendrochronology can be used to help answer that question. The application of this approach to stand dynamics integrates radial growth analysis, species establishment dates, and historic weather records to reconstruct how a stand was initiated and grew into its present state. Dendrochronology is receiving increased usage to reconstruct past disturbance regimes and understand successional dynamics (Mikan and others 1994; Abrams and Orwig 1995) but has only once been used to examine the origin and development of Table Mountain pine communities (Sutherland and others 1995).

In this study, we use dendrochronology to determine when three Table Mountain pine / pitch pine stands originated, how they developed to their present state, and the influence of disturbance and drought on that development.

METHODS

The study was conducted in three stands (Big Ridge, Lower Tallulah, and Upper Tallulah) containing a substantial pitch pine and Table Mountain pine component located in the Chattahoochee National Forest of northern Georgia. The stands were approximately 20-30 ac each, situated on the tops and upper side slopes of two south-facing ridges near Rabun Bald. Elevation for two of the stands was from 3200–3600 ft while the third was at 2800–3000 ft. Soil in all three stands was of the Ashe series which is

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Table 1—Basal area, density, stocking, and relative importance values of tree species found in three Table Mountain pine / pitch pine stands in northern Georgia

Stand	Species[a]	Stems/ac	Stocking	BA/ac	Imp. Value
Upper	QUPR	112	100	55.0	25.75
Tallulah	PIPU	64	77	60.3	20.92
	YSY	82	70	21.2	15.18
	QUCO	39	73	19.2	11.26
	CADE	53	67	0.8	8.87
	ACRU	22	67	5.1	6.87
	OXAR	15	33	8.7	4.90
	QUAL	9	20	11.2	3.95
	AMAR	11	36	2.1	3.58
	SAAL	5	17	1.3	1.65
	ROPS	2	7	1.3	1.01
	CAGL	2	7	0.7	0.53
Big Ridge					
	QUPR	120	100	53.4	21.52
	PIPU	136	100	36.0	19.44
	QUCO	51	86	18.9	10.46
	NYSY	56	71	9.2	8.37
	QUAL	37	57	14.6	7.50
	ACRU	33	64	6.7	6.17
	PIRI	9	43	20.7	6.13
	CADE	40	71	1.1	5.96
	OXAR	13	43	12.0	4.88
	AMAR	20	50	3.5	4.13
	CAGL	9	29	3.5	2.45
	SAAL	4	7	6.9	1.81
	PIST	3	14	2.0	1.17
LowerTallulah					
	PIPU	50	100	37.8	15.96
	QUCO	72	93	30.8	15.61
	NYSY	116	100	11.8	14.92
	QUPR	82	100	21.5	14.86
	ACRU	70	100	7.0	10.83
	PIRI	21	36	30.1	9.44
	CADE	31	50	0.9	4.60
	PIST	15	21	5.2	3.08
	COFL	16	29	2.7	3.00
	CAGL	13	29	1.4	2.53
	SAAL	9	29	2.2	2.42
	ROPS	3	21	3.6	1.60
	OXAR	2	14	3.8	1.22

a - Species codes are the first two letters of the genus and species names, e.g., QUPR = Quercus prinus.

a moderately deep, somewhat excessively well drained soil formed in place by weathering of biotite gneiss and schist (Carson and Green 1981).

In each stand, 12 0.05-ac rectangular plots were selected from previously established plots (Waldrop and Brose 1999) based on presence of Table Mountain pine and location to ensure uniform coverage of the entire stand. In each plot, all trees were identified to species, categorized as dominant, co-dominant, intermediate, or suppressed and measured for dbh. All shrubs were identified to species in two 0.0125-ac rectangular subplots and their heights measured to the nearest 0.5 ft. Percent shrub cover was determined by measuring each shrub canopy twice to the nearest half-foot, first at its widest point then at a right angle to that measurement, averaging the two results, and calculating the area as a proportion of the subplot.

Importance Values (IV) for each species were calculated for each stand from the basal area, density, stocking data.

In each plot, one increment core was extracted from each of three or four dominant/codominant trees and each of three or four intermediate trees. Cores were taken from the uphill side of each tree at a height of 1-ft above the ground in hope of intersecting hidden fire scars. Also in each plot, six to eight cross-sectional discs were cut from shrubs and suppressed trees at the ground line.

Cores were air-dried for several weeks, mounted, and sanded with sandpaper of increasing fineness (120, 220 320, and 400 grit) to expose the annual rings. Cross-sections were similarly dried and sanded. The establishment date for each core and cross-section was determined by absolute aging to the pith under a 40x dissecting microscope. A pith estimator for each species was prepared from cores that intersected the pith and this estimator was then used to age cores that did not intersect the pith.

All pitch and Table Mountain pine cores were visually examined for damage, twisting, or gaps and those exhibiting discongruities were discarded. Annual ring width of the remaining cores was measured to 0.01 mm commencing at the pith and proceeding outward to the bark using a Bannister increment measuring device (J.C. Henson, Laguna Niguel, CA). The raw ring width data were detrended and converted to mean growth indices for each site using ARSTAN (Laboratory of Tree Ring Research, Tucson, AZ).

For ease of reporting the establishment dates, hardwood species of similar silvics were grouped together, i.e., mesic hardwoods included flowering dogwood (*Cornus florida*), red maple (*Acer rubrum*), sourwood (*Oxydendron arborum*), and serviceberry (*Almalanchier alnifolia*) while xeric hardwoods contained American chestnut (*Castanea dentata*), blackgum (*Nyssa sylvatica*), chestnut oak (*Quercus prinus*), pignut hickory (*Carya glabra*), sassafras (*Sassafras albidum*), and scarlet oak (*Q. coccinea*). Mountain laurel (*Kalmia latifolia*), pitch pine, and Table Mountain pine are presented as individual species.

Monthly Palmer Drought indices for Rabun County, GA from 1895 to 2000 were obtained from the National Oceanographic and Atmospheric Administration's website.

RESULTS

All three stands were quite similar in their species composition, structure, density, stocking, total basal area, and relative importance values (table 1). In the overstory, Table Mountain pine and chestnut oak were the dominant conifer and xeric hardwood species, respectively. Pitch pine and scarlet oak were also present in the overstory, although they were not as abundant or widespread as Table Mountain pine and chestnut oak. In the midstory, xeric and mesic hardwoods dominated, especially scarlet oak, blackgum, and red maple while the two pine species were poorly represented. The understory consisted almost exclusively of dense mountain laurel. This shrub layer averaged 8.5 ft tall and was nearly ubiquitous in Big Ridge and Upper Tallulah, cover averaged 77 percent and 89 percent respectively, while in Lower Tallulah, mountain laurel was not as widespread (36 percent coverage). In all three stands, American chestnut stump sprouts were fairly abundant (30-50 stems/acre) and widespread (50-71 percent stocking).

A total of 209 cores and 263 cross-sections was collected from the three stands. Nearly all cores were sound as little difficulty was encountered in extracting them from the trees. Distribution of cores by species group was 47 percent Table Mountain pine, 27 percent xeric hardwood, 17 percent PP, and 7 percent mesic hardwood. Cross-section distribution was 51 percent mountain laurel, 32 percent xeric hardwood, 15 percent mesic hardwood, and 2 percent Table Mountain pine. Thirty of the cross-sections contained exposed or hidden scars. Of those, 19 were from Big Ridge and the scar dated to 1996 (a low-intensity wildfire). The remainder were dated and grouped as 1971 - Lower Tallulah, 4 scars; 1963 - Upper Tallulah, 4 scars; and 1946 - Lower Tallulah, 3 scars. Also at Big Ridge, several large, hollow chestnut oaks and cat-faced pines were found.

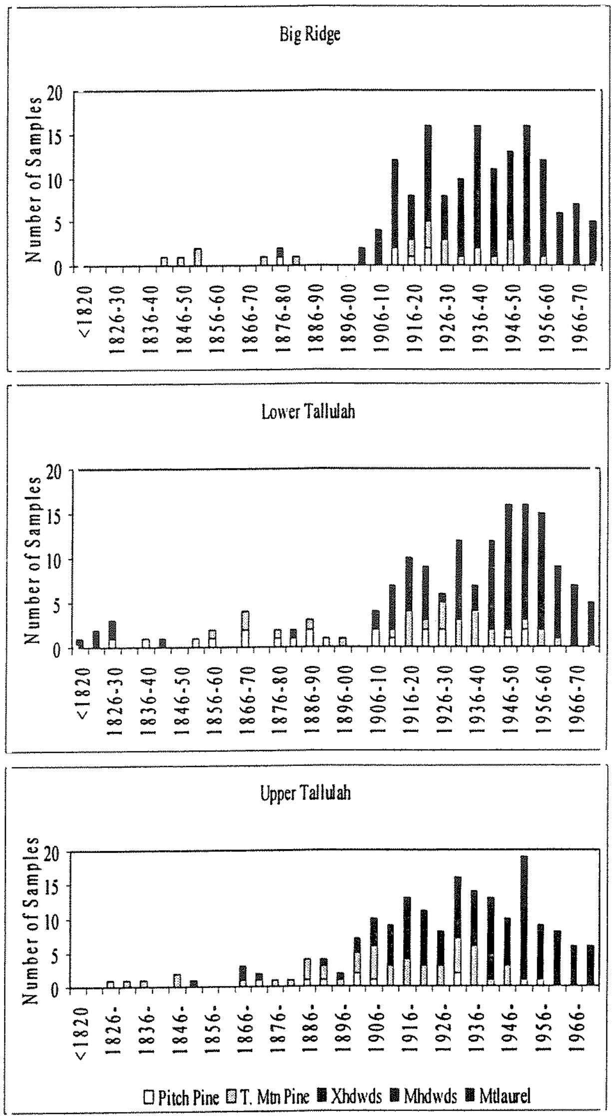

Figure 1—Species establishment dates for three Table Mountain pine stands in northern Georgia.

Species establishment dates and trends were quite similar among the three sites (figure 1). Generally, the oldest trees dated to the early- to mid-1800's and were Table Mountain pine at Big Ridge and Upper Tallulah or chestnut oak and pitch pine at Lower Tallulah. All three species became established in modest episodic amounts during the 19th century. Commencing in the early 1900's and continuing through the 1950's, successful regeneration of Table Mountain pine and the xeric hardwoods (primarily oak) increased relative to the 1800's and were continual in all three stands while pitch pine establishment remained modest and episodic. Pine and xeric hardwood establishment peaked twice in all three stands, first between 1915 and 1925 and again in the early 1930's. Thereafter, establishment of these species declined steadily, eventually ceasing in the late 1950's. Mesic hardwoods, primarily red maple, initially showed up in all three stands beginning in the 1910's and 1920's and were continually established in small to moderate numbers through the 1960's with the 1940's being the decade of most mesic hardwood establishment. Like the oaks, mesic hardwoods have not successfully regenerated in these stands for several decades. Mountain laurel shows up in the stands commencing in the late 1920's. Over the next 50 years it was continually established in large numbers at Big Ridge and Upper Tallulah and to a lesser extent at Lower Tallulah.

The growth index chronologies for both pine species and chestnut and scarlet oak are shown in figure 2. The Table Mountain pine chronologies are fairly robust as the number of trees sampled ranged from 19 to 49. At the two Tallulah stands, growth peaks in the early 1910's, declines until the late 1920's, accelerates until the late 1940's (Upper Tallulah) or late 1950's (Lower Tallulah), then declines until the present. There is no such pattern at the Big Ridge site. In fact, there is no discernable growth pattern at all for Table Mountain pine at Big Ridge.

Pitch pine and oak chronologies are not as robust as Table Mountain pine chronologies because the number of trees sampled is considerably smaller (3 to 21). Among the sites, radial growth patterns for all three species show little similarity to each other nor do they show much similarity to those of Table Mountain pine.

The Palmer Drought Severity Index for 1895 to 2000 is also shown in figure 2. Short-term droughts (1-3 years) were fairly common during the 20th century with especially severe ones occurring in the mid- to late-1920's, throughout the 1930's, mid 1950's, mid 1980's and late 1990's.

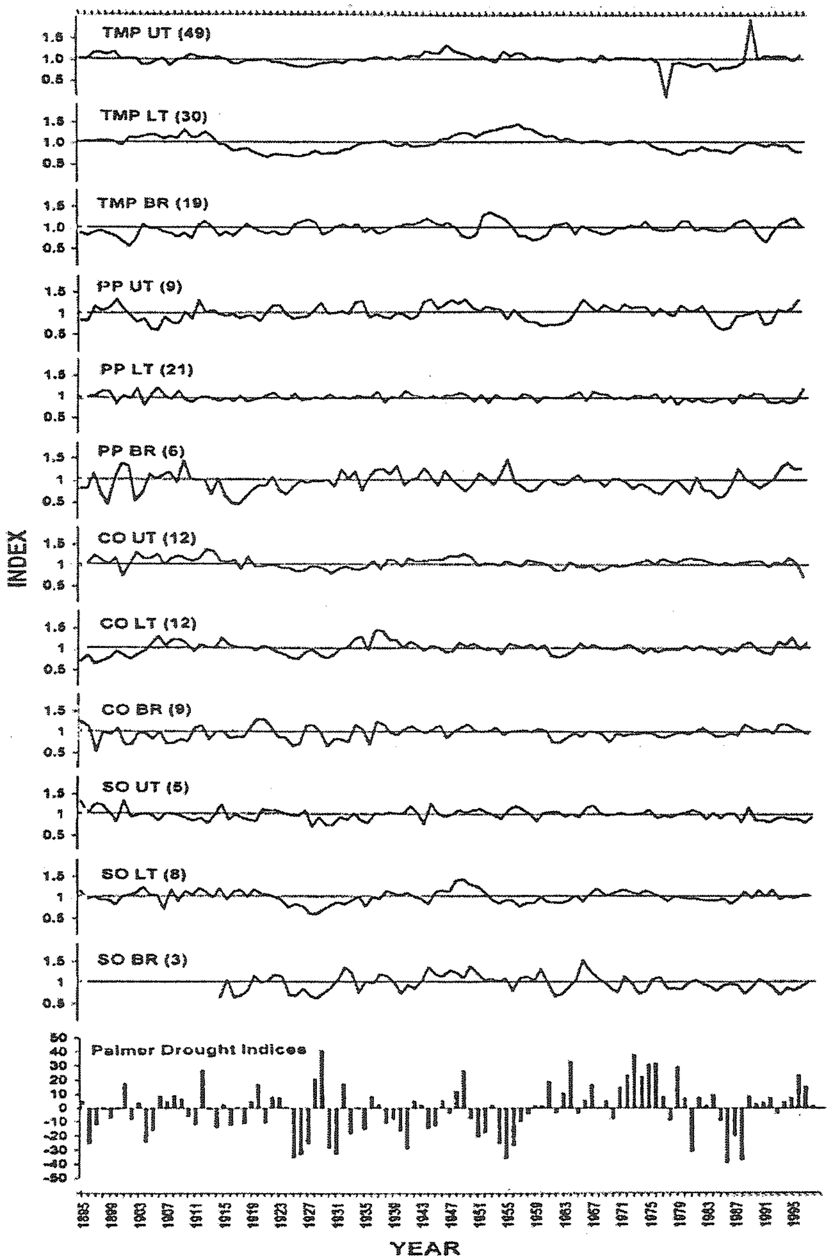

Figure 2—Radial growth chronologies for Table Mountain pine (TMP), pitch pine (PP), chestnut oak (CO), and scarlet oak (SO) and Palmer Drought Indices from 1895 – 2000 for the Big Ridge (BR), Lower Tallulah (LT), and Upper Tallulah (UT) stands in northern Georgia. Numbers in parenthesis indicate sample size.

When compared to species establishment dates in figure 1, drought apparently had little detrimental effect on the regeneration of any of the species.

DISCUSSION

The establishment dates and radial growth data indicate similar, yet different, histories for the three sites. Prior to 1900, these sites supported a mixture of xeric hardwoods (primarily American chestnut and chestnut oak), pitch pine, and Table Mountain pine. Of these, American chestnut probably dominated with the other species forming a moderate minority. The current density and stocking of chestnut stump sprouts (30 to 50 per acre, 60 to 71 percent stocking) indicate the strong position that species formerly held and were probably sufficient to ensure chestnut domination prior to the blight (Paillet and Rutter 1989). Early settlers and travelers often described this forest mixture in this part of Georgia (Plummer 1975).

In that chestnut-oak-pine forest, pitch and Table Mountain pine were able to successfully reproduce but in different patterns. At Upper Tallulah, Table Mountain pine regenerated sporadically before 1865 and continuously after that date. Chestnut oak and pitch pine regenerated episodically during the same time at this location. At Lower Tallulah, all three species regenerated sporadically during the 1800's while only Table Mountain pine successfully regenerated in discrete episodes at Big Ridge.

Apparently, the pre-1900 disturbance regime was conducive to successful regeneration of Table Mountain pine, especially at the Upper Tallulah site. Given the continuous establishment of Table Mountain pine between 1865 and 1900, the lack of rot in the oldest trees, and a near absence of scars in cross-sections, it does not appear that fire was a severe disturbance agent at this site. At Big Ridge and Lower Tallulah, fire may have been more frequent and/or severe, resulting in the episodic regeneration patterns throughout the 1800's.

However, frequent (2 or 3 fires per decade), low-intensity fire may have occurred in all three sites. Such a fire regime would allow some Table Mountain pine regeneration to persist, encouraging establishment of more seedlings, and not causing widespread bole damage to overstory trees. Frequent, low-intensity fires would also encourage regeneration of oak by creating seedbeds and eliminating fire-sensitive competitors (Barnes and Van Lear 1998, Waldrop and Brose 1999).

In the early 1900's, a major disturbance event occurred at all three sites as evidenced by a drop or complete absence of oak and pine regeneration at that time followed by a tremendous establishment surge for 10 to 15 years. Radial growth trends of Table Mountain pine also show an increase at that time, indicating some type of release event. At Big Ridge, this disturbance was undoubtedly a severe fire that few trees survived. Those that did still carry fire scars and/or internal rot. The two Tallulah stands may have experienced some selective logging instead of fire at that time as they probably had more chestnut and are more accessible than Big Ridge. Logging of chestnut became common in the early 1900's when it became evident that the blight was unstoppable (Keever 1953). Also indicating that a severe fire did not occur at that time, trees predating 1900 are more numerous and usually sound, and fire-sensitive, mesic hardwoods begin to be successfully established.

The next major disturbance was in the late 1920's. By that time the American chestnuts that had been killed by the fire or logged would have sprouted, grown into the pole stage, and were probably expressing canopy dominance. The blight killed these developing stands, releasing the codominant oaks and pines, as evidenced by the radial growth increase in Table Mountain pine starting about 1927, and initiating a surge of oak and pine regeneration. Immediately thereafter, establishment of mountain laurel commenced and since then this shrub has come to dominate the understories in all stands, causing all tree regeneration to gradually wane and eventually cease.

Since then, disturbance in these stands appears to have been minimal. Low-intensity surface fires likely occurred in 1946, 1963, and 1971 in the two Tallulah stands but these events impacted only small areas. An outbreak of southern pine bark beetle probably happened in the early 1950's as evidenced by a surge in hardwood and laurel regeneration but not in pine reproduction.

CONCLUSIONS

These Table Mountain pine stands are the product of severe disturbance (fire, logging, and the chestnut blight) followed by decades of little disturbance. The role of occasional low-intensity surface fires in pine regeneration prior to 1900 was probably important but clearly identifying that role was not possible given the analytical limitations of this study. The lack of severe disturbance since the 1930's has allowed mountain laurel to become established and spread. These stands will eventually convert almost entirely to mountain laurel thickets with a few scattered overstory trees if this shrub is not controlled. However, even a severe disturbance may not change that outcome if it is a singular event. To restore these stands to a successfully regenerating oak/pine mixture, numerous low- to moderate-intensity disturbances (herbicide, mechanical, and/or prescribed fires) over a decade or more are needed to remove the laurel and prepare seedbeds.

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